The Solar System – Exercise classes

Problem Set 4

Distributed: 4 Nov 2024, results due: 11 Nov 2024.

Problem 4.1

Estimate the surface temperature of Earth if it were a blackbody and only heated by the 90 mW/m^2 coming from inside. *(1 point)*

Problem 4.2

A planet's lithosphere is typically confined to the upper layers where the temperature does not exceed ≈ 1200 K. Calculate the limiting depth of Earth's lithosphere, assuming a heat flux density of 90 mW m^{-2} from the interior and a thermal conductivity of 3 W m^{-1} K^{-1}. *(1 point)*

Problem 4.3

Estimate the total gravitational energy transformed into heat during the agglomeration of Earth and Jupiter, respectively. If that heat had been released at a constant rate over the past 4.5 Gyr, what heat flux densities (in W/m^2) would have resulted at the surfaces of the two planets? Assume that the planets have constant mass densities. *(2 points)*

Bonus problem 4.4

For every radioactive decay of a ^{40}K atom (half life of $t_{1/2} = 1.248 \times 10^9$ yr) an energy portion $\Delta E = 1.3$ MeV $= 2.1 \times 10^{-13}$ J is released as heat. Assume a homogeneous asteroid (with $\rho = 2$ g/cm^3) that contains a fraction of 0.02 % by mass in K, of which again a fraction of 0.15 % is in the isotope ^{40}K. Let the material's heat conductivity equal 2 W m^{-2} K^{-1}. What is the critical asteroid size above which the (equilibrium) core temperature exceeds 1000 K? *(2 points)*

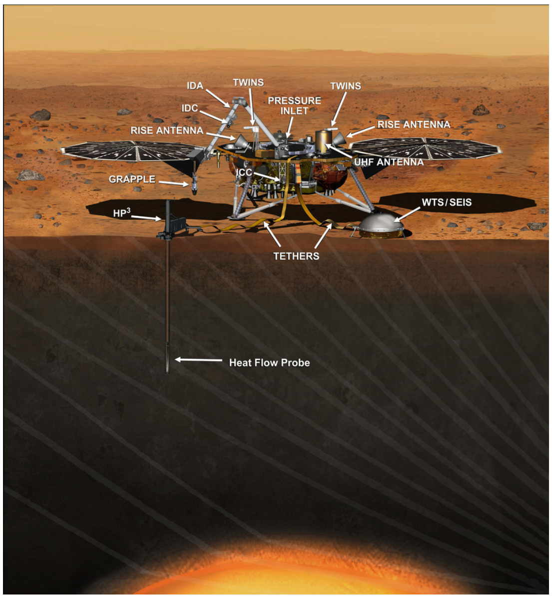

Figure 1: Artist's impression of the InSight lander (touch-down on 26 Nov 2018) with its instruments, including the seismometer SEIS and the underground "thermometer" HP^3, the latter of which suffered from problems during the drilling process. (NASA/JPL-Caltech)

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